Norwegian National Program for Lifetime Commissioning and Energy Efficient Operation of Buildings

Vojislav Novakovic, Natasa Djuric, Johnny Holst,
Norwegian University of Science and Technology
Department of Energy and Process Engineering
N-7491 Trondheim, Norway

Frode Frydenlund
SINTEF Energy Research
N-7491 Trondheim, Norway

Vojislav.Novakovic@sintef.no

Abstract: The project "Life-Time Commissioning for Energy Efficient Operation of Buildings" is actually a network of industrial companies, private and public entities, and R&D organizations. The overall objective of the project is to contribute to the implementation of life-long commissioning of building HVAC systems, so that this becomes a standardized way of building, operating and maintaining the HVAC systems in Norway. The project is organized as an industry research program with minimum duration of five years. Project members pay an annual membership fee. The main goal for the project is to develop, verify, document and implement suitable tools for functional control of energy and indoor environment in buildings under continuous operation during the entire operational life of the building. This will improve energy efficiency and ensure a rational use of energy and a sound indoor environment. All achievements concerning energy improvement will also contribute to the decrease of CO_2 emissions.

1. INTRODUCTION

All serious industry actors involved in procurement, planning, construction and operation of buildings have good intentions with regard to achieving the requirements of efficient and safe operation, a sound indoor air environment, rational use of energy, minimal impact on the outdoor environment, as well as sound economy over the building's lifetime. Practical experience, however, shows that in way too many cases there are serious discrepancies between assumptions and goals on one side, and the reality on the other side. Some problems are already present at the handover of the building and testing of the technical installations, while others surface after the building has been in operation for some time. Smaller errors leading to hidden deviations may never be found.

The situation described above holds true both for Norway and for most other countries in the world. In 1999, the International Energy Agency's (IEA) Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS) initiated the activity "Annex 40: Commissioning of Building HVAC systems for Improved Energy Performance" (Visier, 2005). All together, ten countries participated and three others had observer status. In most participating countries national activities were conducted and national support teams were established. In 2005 the same Implementing Agreement decided to launch a new activity that is a continuation and further development of the previous: "Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings" (Choiniere, 2005). The new Annex is now in a one-year Planning Phase.

Over the last twenty years, Norwegian energy authorities have focused on energy conservation. This has lead to development and a gradual improvement of measures. Finally the particular energy efficiency method called "energy administration" has been developed. Lately, a national project for "Life-Time Commissioning and Energy Efficient Operation of Buildings" (the LTC Project) (Novakovic, 2005) has been initiated.

2. NORWEGIAN ENERGY AND ENERGY CONSERVATION POLICY

The Norwegian State's interest in energy conservation closely followed international trends in

this area. The first Norwegian White Paper to deal with energy conservation appeared in 1979, and for the first time, the National Budget included items earmarked for energy conservation. Since then, no fewer than five White Papers on energy conservation have appeared, the last one in 1998. In 1992, a completely new Energy Act introduced the power of the market to electricity sales. This was intended to guarantee that energy resources would be managed rationally and for the benefit of society as a whole. The "balance clause" in the Energy Act also required energy conservation to be regarded as a means of meeting energy demand on an equal footing with new development and purchases of energy on the market.

The aim of public sector interest in energy conservation in Norway is to help ensure that energy resources are utilized in a macro economically efficient way and that the harmful environmental effects of energy consumption are reduced. Until 1990, national energy conservation activities basically consisted of information, training and development of know-how. Research and demonstration projects were also given support mainly for the development of new, energy-friendly technologies. The authorities have also allocated funds for the implementation of energy conservation measures in their own buildings. Since 1990, funds have been allocated for the implementation of energy conservation measures in industrial and commercial buildings, as well as in local authority and county council buildings. In 1992, a subsidy scheme for private dwellings was also introduced.

During the second half of the 90s, authorities appointed agents for public information, for energy efficiency in industry and buildings. Regional centers for energy efficiency were established in Norway's nineteen counties. These centers received the responsibility for introduction of simplified energy surveys and for motivation of building owners for further investment in comprehensive energy audits and in subsequent energy efficiency measures. Energy monitoring became a mandatory part of the measures. The agent for energy efficiency in buildings initiated dedicated energy efficiency networks connecting building owners for particular types of buildings. The importance of energy administration was deeply rooted in management of the whole building and real involvement of the owner was pinpointed.

A public enterprise, Enova SF, owned by the Royal Norwegian Ministry of Petroleum and Energy was established in 2002. Enova`s mission is to contribute to environmentally sound and rational use and production of energy, relying on financial instruments and incentives to stimulate market actors and mechanisms to achieve national energy policy goals.

2.1 Energy Efficiency Practice In Buildings In Norway

Current energy efficiency practice in Norway contains four closely connected areas:

- Energy survey
- Energy audit
- Energy monitoring
- Energy administration

These four activities reflect the experience gained through implementation and development of the methods during the last twenty years. During the 1980s with focus on simple energy efficiency, the concept of energy audits was established. Later in '90s the concept was divided into a simplified energy survey and a comprehensive energy audit. The next step was energy monitoring and the last extension is energy administration.

The energy administration method has been developed due to experience gained during the years. Energy efficiency projects initiated by the operational staff or others further down in the organization showed less possibility to be executed. This is explained by the fact that the building management has traditionally had little interest in energy consumption and energy efficiency. To change this behavior, a process called energy administration, which actively involves both the building owner and the manager, has been introduced.

2.2 Commission Activities in Norway

Traditionally, in Norway the commissioning process for large buildings has been looked upon as the completion and take-over. It has not been considered to be a process from the start of the building project to the end of the lifetime of the building.

The regulations in Norway describe the formalities concerning the take-over process, like the contents of the completion protocol, routines for alteration work, procedures in the take-over etc. It does not consider any routines along with the progress of the building project. Some major building owners have established separate commissioning routines based on approaches from, for instance, the offshore industry and the pharmaceutical industry.

The EC directive 2002/91 on energy performance of buildings, sets a framework for calculation of energy demands and for energy certification for each building. In addition it puts guidance on arrangements for inspections and control to see that the directive is followed. Even though the directive does not deal with commissioning, a proper commissioning process will be one tool to fulfill the directive.

The development of all particular elements of energy efficiency methods prepared necessary ground for understanding and interest for implementation of the concept of commissioning. Two basic needs for successful commissioning are a committed building owner and accurate procedures for conducting all processes during the entire building lifetime.

3. RESEARCH TASKS

There is an increasing awareness that many buildings do not perform as intended by their designers. Reasons include faulty construction, malfunctioning equipment, incorrectly configured control systems, and inappropriate operating procedures. Changes in the use or configuration of buildings without subsequent changes in systems or operating practices often contribute to these problems. Occasionally, the problems are caused or compounded by design errors.

Proper energy use and indoor environment performance can be achieved by continual commissioning stretching from pre-design to on-going supervision of performance.

The main goal of the LTC Project is to map, adapt, and develop systematics and a methodology known from the building industry and other industry, and from international cooperation. The systematics and methodology will be based on manual and computerized methods.

The building process can be divided into three main phases: the design phase, the construction phase and the operational phase. Project activities will be divided into work packages according to the different phases (see Figure 1).

3.1 The Design Phase (Work Package 1)

The focus is on development of a methodology and systematics ensuring the owner's project requirements (OPR) are put into the bid specifications developed during the design phase in a way that ensures performance verification in an early stage.

The level of details will vary with the size and complexity of the project, the demands of the owner, and the experience of the design team. The OPR should describe how the project will be used and operated, and should present known goals and objectives as measurable metrics when possible. It may also state specific contractual performance requirements or energy consumption targets, if established by the owner. The OPR sets the criteria for all subsequent design decisions.

3.2 The Construction Phase (Work Package 2)

The focus in this phase is to develop uniform verification checklists and pre-functional test procedures that are used to ensure that equipment is properly installed and ready for functional testing

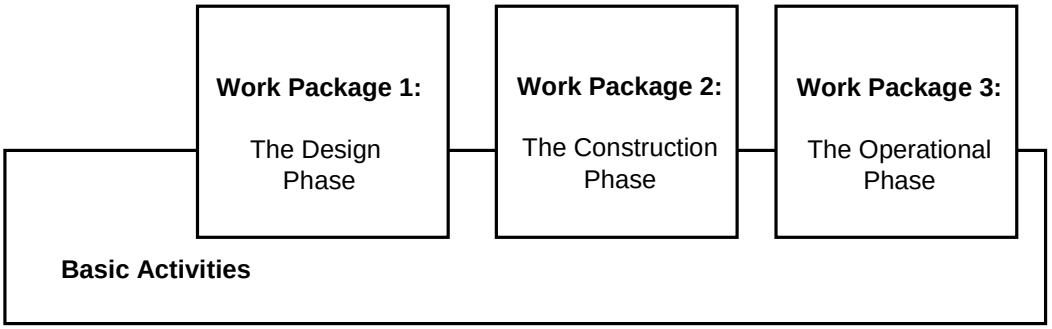

Fig. 1. Work packages and project contents

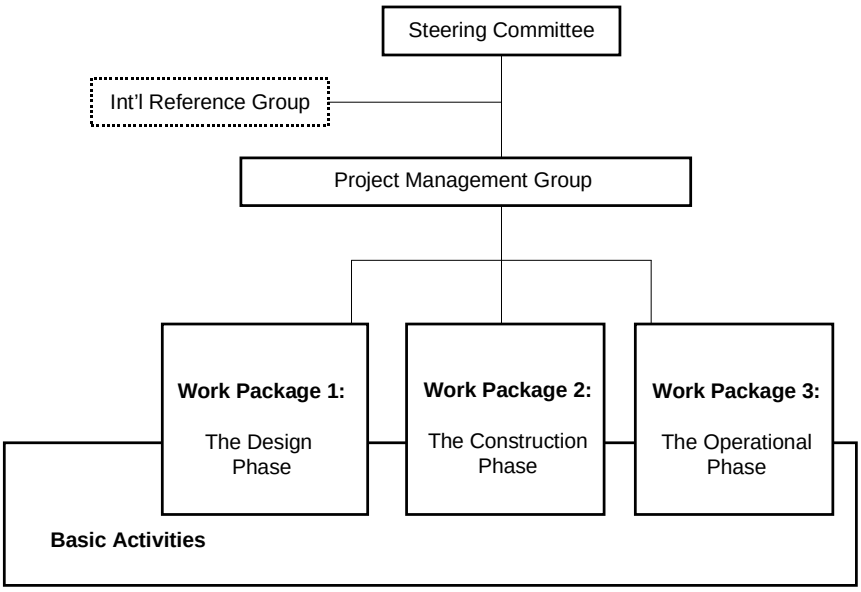

Fig. 2 Organization of the project

3.3 The Operational Phase (Work Package 3)

For new buildings, the methodology and systematics will ensure safe and effective operational system design. But buildings need to be followed up with a close reporting to the different actors in the process. This reporting gives the actors the means to properly prioritize and to act early if necessary.

For existing buildings, the focus is on developing methods for retro commissioning. Retro commissioning begins with the planning phase, which consists of identifying project objectives, targeting systems for improvements, and defining tasks and responsibilities. A plan for conducting the work is the result. An investigation phase follows, in which on-site assessment and testing are conducted. This phase allows deficiencies to be found and the scope of work to be refined.

Once the scope is finalized, the improvements are then installed in an implementation phase, and their success is validated.

Finally, the completed improvements are handed over to the owner along with information and knowledge gained during the process to help ensure long-term performance for the owner.

3.4 Basic Activities

The LTC Project will produce two PhD candidates and the following themes are under processing:

- Real-time supervision of Building HVAC system performance
- Online measurement for continuous functional control

Different themes for the Master projects and thesis are and will be developed at later stages following the procedures at NTNU. Both PhD and Master activities will be linked with relevant LTC Project activities.

3.5 List of Activities

Below is a list of the most central activities. These activities are related to all three work packages.

1) Convert existing procedures from the building industry, international cooperation and other industries.

2)Develop manual procedures for ongoing commissioning.

3)Visualize an improved systematics in the building construction industry.

4)Develop simulation procedures for ongoing commissioning of energy and indoor environment performance in buildings (real time supervision, PhD).

5)Establish good demonstration projects for ongoing commissioning.

6)Establish international research cooperation (participation in the IEA project).

7)Establish good connection between Norwegian building industry and RD-environment.

8)Update and refresh the relevant courses in the Master Programme at NTNU.

9)Revitalization of the continued education for the building industry and develop a new course within this field.

Since the members will also have a say in the development of the LTC Project contents, the list will more than likely be supplemented and revised during the LTC Project period.

4. RESEARCH APPROACH AND METHODS

The objective and sub-goals of the LTC Project will be realized through several clearly defined activities. The Steering Committee will make priorities regarding the activities. Each activity will be defined with goals, budget and a time plan.

Personnel employed at the "Gemini-Center Energy Supply and Climatization of Buildings" at NTNU[1] and SINTEF[2] will perform the majority of the activities. When appropriate, students and personnel from the member companies will also take part in activities. Students will be offered project assignments and Master theses relevant to the LTC Project activities, or shorter engagements like for instance summer jobs. For larger and more research-based activities we will initiate PhD projects.

The development and testing of methodology, systematics and procedures will be typical tasks where it is natural with cooperation between scientists and participants from the building industry. Planning and carrying out demonstration projects will also demand close cooperation between scientists and participants from the building industry.

Development and verification of suitable simulation programs for continual commissioning of energy and indoor performance in buildings, is a huge research task and will demand high professional qualifications and concentrated effort over a long period of time. This will be a typical PhD project.

5. IMPORTANCE TO NORWEGIAN INDUSTRY

The following are the primary target groups for the project:

• Building owner, who can control whether the functioning of the building and its energy and indoor climate conditions during operation are in accordance with the intentions set during the design phase

• Project leaders and entrepreneurs, who can minimize the risk for budget and time overruns, as well as ensure correct building quality

• Designers and entrepreneurs, who want to ensure that the function of the building and its energy and indoor climate conditions both at handover and during operation are in accordance with plans

[1] NTNU – Norwegian University of Science and Technology

[2] SINTEF - The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology

• Those responsible for operations, who wish to control and improve the functioning of the building and its energy and indoor climate conditions during continuous operation

• Suppliers of automation systems, who can improve and further develop their systems for central operation

• Authorities, who wish to ensure a rational use of energy resources, minimize environmental strain, and sound health and high productivity for workers

During the initial phase of the establishment of the Project, we have concentrated on attracting for participation building owners who will set premises for application of the new method for lifetime commissioning.

If implemented successfully, the new methodology will have the potential of:

- Saving a considerable amount of energy
- Reducing costs for building owners
- Improve indoor air climate, and thereby, productivity for owners.

6. PROJECT ORGANIZATION AND MANAGEMENT

The LTC Project is organized as an industry research program with private companies, organizations, and institutions signing up for membership (see Figure 2). The LTC Project is made up of the executing entities NTNU and SINTEF and members from industry and the public sector. Project members pay an annual membership fee. The annual fee is NOK 200.000 for full membership. A limited membership, with fewer
return services, for companies not able to contribute the full fee is NOK 75.000.

The LTC Project was formally launched in May 2005 with the intention that it will have a minimum duration of five years. The members sign up from year to year and, consequently it will be possible to withdraw from the LTC Project with a six months notice.

The Steering Committee, which meets 2-3 times per year, is responsible for development of the work program and will approve activities to be started. If a limited membership is introduced, only those paying the full membership fee will have the right to a seat in the Steering Committee.

At this time the LTC Project has the following participants:

• Full Membership:
- Norwegian Telecom (real property division)

• Limited Membership:
- Statoil (real property divisions)
- Statsbygg – Norwegian Directorate of Public Construction and Property
- Enova SF
- ProTeknologi

• Associated Membership:
- Forsvarsbygg - Norwegian Defence Estates Agency

The associated membership is established just as a temporary stage while the participant is waiting for the formal decision on membership level.

7. THE FIRST ACTIVITIES REALISED IN THE LTC PROJECT

7.1 The Survey of Existing Buildings

The survey of existing buildings that could be used for commissioning (Djuric, 2006) is a preliminary first step of the LTC Project. The survey is carried out by developing the questionnaire for building caretakers in the buildings owned by members of the LCT Project. The survey has two aims. The first is to make an overview of the most typical buildings, HVAC equipment and their related problems. The second aim is to establish the criteria for both choosing the buildings in the further research and establishing the existing building commissioning tools.

Currently the answers have been received from 32 buildings. Three companies sent their answers from 15 towns. The ages of buildings are from one to 96 years.

Considering current results from the questionnaire the future research will be concentrated on the buildings with the persistence in renovation,

and with Building Automation System (BAS). The research will treat the buildings, which have available documentation and energy bills. Also, the future work should try to develop the commissioning tools for the following problems: draft, noise, bad air, spaces that are too warm or too cold, and unstable temperature.

This study (Djuric, ICEBO 2006) will be elaborated at the ICEBO 2006 Conference.

7.2 Methods for Collecting and Transferring Design and Commissioning Information

Commissioning is a process that plays an important role in the design of modern buildings. The commissioning process must start early in the design process, and follow through the building process and into the operation of the building. In this process there is a huge amount of information that needs to be collected and transferred to the different participants in the process.

This activity comprises development of a set of assisting methods so that the designer, the commissioning authority and the operational staff can meet the goals that have been set in the different phases of the building design and construction.

The different methods allow sharing and avoid losing information through the different phases. The methods also ensure that all design decisions that have implications for operation of a building, have undergone necessary verification and will be as optimal as possible.

The methods are under development and are planned to be implemented into a prototype software tool. This prototype will be especially important in developing optimal operational strategies and commissioning procedures.

8. CONCLUSIONS

The Project for “Life-Time Commissioning and Energy Efficient Operation of Buildings” is a network of industrial companies, private and public entities, and R&D organizations.

The overall objective of the research project is to contribute to the implementation of life-long commissioning of building HVAC systems, so that this becomes a standardized way of building, operating and maintaining the HVAC systems.

The main goal for the project is to develop, verify, document and implement suitable tools for functional control of energy and indoor environment in buildings under continuous operation during the entire operational life of the building. This will improve energy efficiency and ensure a rational use of energy and a sound indoor environment.

Judging by the interest and the activity level of the involved project members the Norwegian LTC project has a fair chance of success.

REFERRENCES

[1] Visier, J.C. et al: “Commissioning tools for improved energy performance - Results of IEA ECBCS ANNEX 40” – Final report, June 2005, Paris, France.

[2] Choiniere, D., Castro, N.: “New IEA ECBCS Annex Proposal: Cost-Effective Commissioning for Low Energy Buildings”, April 2005.

[3] Novakovic, V. et.al.: “Life-Time Commissioning for Energy Efficient Operation of Buildings”, Application for a KMB Project, September 2005.

[4] Djuric N., Frydenlund F., Novakovic V., Holst J., Aarlien R.: Preliminary step in collecting data for commissioning of existing buildings (Characterization of buildings, systems and problems), Working Document, IEA - ECBCS Annex 47 Second Meeting, Cost-Effective Commissioning for Existing and Low Energy Buildings, Trondheim, 2006.

[5] Djuric N., Novakovic V., Frydenlund F.,: “Existing building commissioning using computer based tools”, The 6th International Conference for Enhanced Building Operation (ICEBO 2006), Shenzhen, China, November 2006.